Computers & Education 80 (2015) 95–107

Contents lists available at ScienceDirect

Computers & Education

journal homepage: www.elsevier.com/locate/compedu

Exploring the antecedents of screenshot-based interactions in the context of advanced computer software learning

Travis K. Huang*

Department of Information Management, College of Information Science, Ling Tung University, 1, Ling Tung Rd., Taichung 408, Taiwan, ROC

ARTICLE INFO

Article history:
Received 9 May 2014
Received in revised form
21 August 2014
Accepted 21 August 2014
Available online 3 September 2014

Keywords:
Computer-mediated communication
Interactive learning environments
Media in education
Teaching/learning strategies

ABSTRACT

Current e-learning systems provide course materials in a variety of formats, such as text, image, and video, and students are able to interact with their classmates and teachers using discussion forums, chat rooms, or e-mail. However, most interactions between students seeking technical support have a textual format. To promote effective discussion and interaction between users, e-learning systems should make better use of a variety of media. According to media-richness theory, screenshots are the best medium for describing problems and troubleshooting in the context of computer software. This study developed a screenshot-based interaction system, which is a system of discussion forums for advanced computer software learners, by integrating the richness of social-networking media with the traditional structure of present-day discussion forums. The system provided students with a convenient, clear means of explaining advanced computer software problems, by uploading screenshots, dragging rectangles, and leaving comments in text boxes. It also allowed students to give and receive individual responses to their problems, thereby enhancing their learning. As all of the interactions, including the description of the problem and the subsequent responses, were based on screenshots, they were termed "screenshot-based interactions." The study investigated the effects of five antecedents of user intention to conduct a screenshot-based interaction, including colleague opinion, personal innovativeness, perceived enjoyment, perceived ease of use, and perceived usefulness. The results, based on data collected from 418 students, indicated that students' perceived enjoyment, perceived ease of use, and perceived usefulness had a strong, positive, and direct effect on their behavioral intention, whereas personal innovativeness had an indirect effect. Colleague opinion had direct effects on their perceived enjoyment and perception of the system's ease of use and usefulness, which in turn indirectly affected their behavioral intention.

1. Introduction

Over the past two decades, technology has changed the way we learn. From books on paper to books in browsers, training CDs and DVDs to video streamed on the Web and even in apps, it is becoming more and more convenient for people to explore information on the go. In the field of e-learning, there are many different types of virtual environment for enhancing learning via electronic media, but they all have similar functions (Ngai, Poon, & Chan, 2007; Sanchez & Hueros, 2010). For instance, current e-learning systems provide course materials in a variety of formats, such as text, image, and video, and students are able to interact with their classmates and teachers using discussion forums, chat rooms, or e-mail. However, interactions with individuals providing technical support, who are defined as "people trained to help users in solving problems related to computer hardware and software" (Ralph, 1991), usually occur in textual format. Media-richness theory (Daft & Lengel, 1986; Daft, Lengel, & Trevino, 1987) states that higher-richness media can be used to enhance shared meaning and understanding by reducing the degree of equivocality or uncertainty when problems are proposed for further discussion. Hence, those developing e-learning systems should make good use of media to promote effective discussion and interaction between users, as well as providing instructional materials in different media.

* Tel.: +886 4 7628138.
E-mail address: travisk.huang@gmail.com.

http://dx.doi.org/10.1016/j.compedu.2014.08.011
0360-1315/

There are three major categories of computer software: system software, programming software, and application software. System software, such as device drivers or operating systems, provides the basic functionality for computer usage, and is responsible for the management of a variety of independent hardware components, whereas programming software provides tools for coding computer programs or using programming languages. Application software is developed to perform specific tasks, and encompasses software of many kinds, such as business software, word-processing software, image-editing software, spreadsheet software, and telecommunications software. It is usually more difficult to use system software and programming software than application software, and correspondingly easier to become skilled in application software than in advanced computer software such as system software or programming software. In the latter cases, users may not have a clear picture of their situation, and may not even know how to describe their problems. This hinders the acquisition of computer-software skills, especially advanced computer software skills. As a result, users need either technical support to diagnose their problems, or the provision of an e-learning system that facilitates discussion and interaction by making good use of higher-richness media, rather than text alone.

Computer-based social annotation has matured (Chen, Hwang, & Wang, 2012; Gao, 2013); people can easily make text-based annotations on a webpage by highlighting a specific portion of the text and leaving a comment. Several studies have revealed the positive effects of annotation systems on learning performance (Hwang, Wang, & Sharples, 2007; Samuel, Kim, & Johnson, 2011; Su, Yang, Hwang, & Zhang, 2010). For example, when discussing a difficult problem, an argumentative diagram tool, which has greater richness than text, would be much more useful than a text-outline tool (Munneke, Andriessen, Kanselaar, & Kirschner, 2007).

Social-networking sites have become the preferred forum for social interaction among the Net generation. People tend to interact with each other through these websites by texting, talking, playing games, or sharing photos. Some social-networking sites, such as Flickr and Facebook, furnish users with a highly interactive photo-sharing environment, which allows users to create additional tags or text boxes for photos posted. Using a mouse to drag and click, a member can easily create a free-width and free-length rectangle located anywhere on a photo. To respond more specifically to photos, users can ask questions or share their opinions by leaving comments in new text boxes next to the rectangle. This kind of photo-sharing environment inspired the development in this study of a screenshot-based interaction system using higher-richness media, which allows users to post screenshots rather than personal photos.

A screenshot, also known as a screencap, a screen dump, or a print screen, is a snapshot of all of the items visible on the computer screen. As screenshots are digital images, they can be captured by cameras, webcams, and smart phones, by a specific application, or even by an operating system such as Windows 8 or Linux. As we know, a picture is worth a thousand words. Screenshots are a more intuitive means of describing a computer problem than words, and are widely used to demonstrate the status of a software program, such as running, sleeping, paused, or stopped. When users encounter particular problems with their computers, describing their screen output to others using screenshots is very helpful. Screenshot interaction may thus be a more effective method of describing computer problems and trouble-shooting software than text alone.

This study involved the implementation of a screenshot-based interaction system, which is a new system of discussion forum for advanced computer software learners, by integrating rich social-networking media, specifically screenshots, with the structure of

Fig. 1. Pinpointing a response to a screenshot.

traditional discussion forums. In short, the screenshot-based interaction system is a discussion forum using higher-richness media, and can be regarded as an extension of traditional discussion forums, which are mostly in textual format. When a student uploads a screenshot to the system, accompanied by a description of the problem, other students are able to diagnose and solve the problem with greater certainty. In addition, when a user wishes to respond to the screenshot, he can pinpoint the subject of his enquiry by dragging a rectangle above the screenshot and leaving comments in another text box, as shown in Fig. 1. As the entirety of the interaction, including the description of the problem and the subsequent responses, is based on a screenshot, this kind of interaction is termed a "screenshot-based interaction."

When a student uploads a screenshot, other students may interact with the screenshot by creating rectangular text boxes in which to leave comments. For instance, as shown in Fig. 2, four rectangles and four text boxes are positioned above a screenshot. All screenshot-based interactions are thus accessible by all participants, including students and their teachers. Moreover, this kind of screenshot-based interaction not only provides students with an efficient way to explain their advanced computer software problems, but also helps them to understand these problems. It is clear, therefore, that screenshot-based interactions may enhance students' learning.

The emergence of social-networking media has increased connectivity within society. As people tend to rely heavily on peer-to-peer interaction, they have swiftly adopted the new media formats (Dickinger, Arami, & Meyer, 2008). After implementing the screenshot-based interaction system, therefore, it was necessary to examine user acceptance of conducting screenshot-based interactions. Several models were considered, including TRA, TPB, TAM, TAM2, UTAUT, and TAM3, from which a technology-acceptance model (TAM) (Davis, Bagozzi, & Warshaw, 1989) was chosen to measure user acceptance. This decision was due, first, to the widespread use of TAM over the past two decades to predict and explain user acceptance of new information technologies (IT). Second, this model is sufficiently extensible and flexible to include other context-specific constructs. In addition, much MIS research has shown TAM to be a valid means of explaining users' adoption of various IT tools and methods (Adams, Nelson, & Todd, 1992; Chin & Todd, 1995; Chow, Herold, Choo, & Chan, 2012; Doll, Hendrickson, & Deng, 1998; Segars & Grover, 1993).

An increasing number of recent studies have used motivational theory to interpret individuals' behavior in response to e-learning systems and in knowledge-sharing communities. For instance, Sanchez and Hueros (2010) examined the extrinsic and intrinsic motivations of users of the Moodle system, which is a Web-based learning platform. Gao, Dai, Fan, and Kang (2010) identified social-emotional rewards as an important factor influencing the utilization of social software, such as e-mail, instant messenger, forums, blogs, and social-networking services. In addition, Yang and Lai (2010) found intrinsic motivations, such as enjoyment, to positively affect individuals' willingness to share knowledge in Wikipedia. As the screenshot-based interaction system developed in this study made use of a highly interactive medium, users' perceived enjoyment was considered a critical factor in determining user acceptance.

In addition, users tend to concur with their colleagues' opinions of new information technologies (Lewis, Agarwal, & Sambamurthy, 2003). Kim and Kankanhalli (2009) found that favorable colleague opinion has a negative effect on user resistance. In other words, colleague opinion seems to have a positive influence on users' willingness to adopt new information technologies, and was thus treated as another antecedent of TAM in the present study.

According to the diffusion-of-innovations theory (DIT) (Rogers, 1995), users' personal innovativeness has a significant influence on the speed of their adoption of new technologies and ideas. For example, users' need for innovation is related to their adoption of a personal

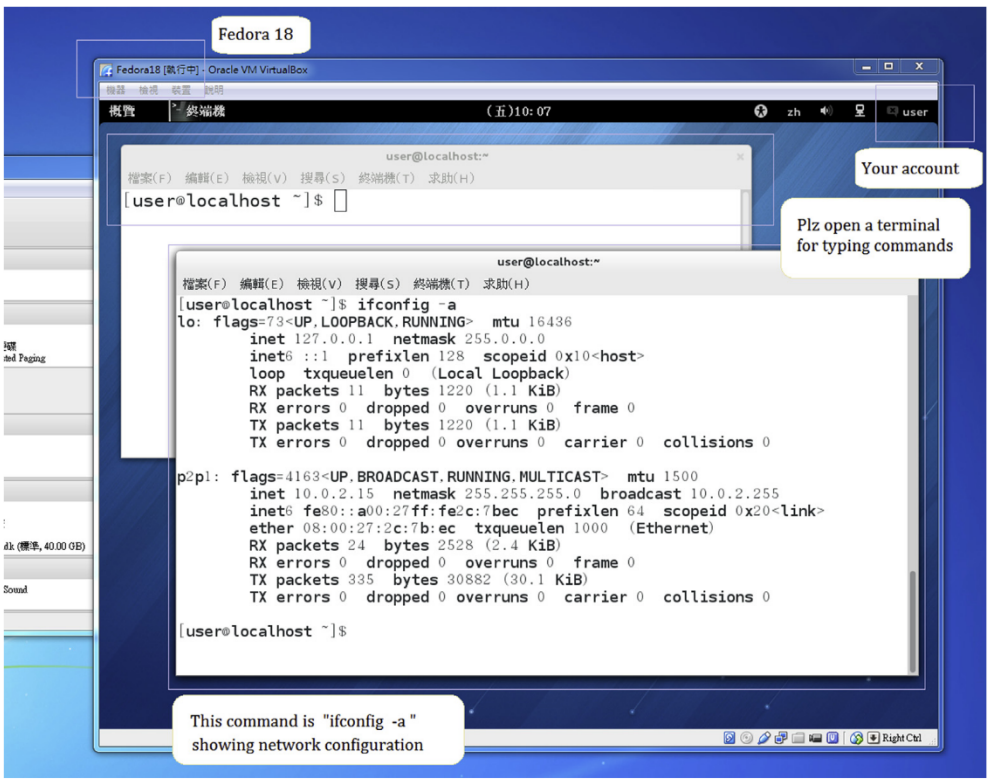

Fig. 2. An example of screenshot-based interaction.

computer (Lin, 1998) and their use of webcasting (Lin, 2004). To realize this need, they must anticipate and keep up with innovative ideas (Lin, 1998). In this regard, people with a greater desire for novelty may be more willing to adopt an innovative idea or method (Hirschman, 1980). According to the diffusion-of-innovations theory, therefore, the development and diffusion of new ideas and technology is determined by the innovativeness of individual users. More specifically, this has been identified as another factor encouraging users to adopt new information technologies.

This study investigated user acceptance of conducting screenshot-based interactions in the context of advanced computer software learning. The subjects of the study were undergraduates taking courses in advanced computer software, specifically the Linux operating system, and the information technology addressed was actual screenshot-based interaction. In addition to applying TAM, three context-related factors were chosen as the basis for the research model, namely perceived enjoyment, colleague opinion, and personal innovativeness. The study aimed to answer the following questions: What are the fundamental relationships expressed by TAM when users are conducting screenshot-based interactions to explain their problems and obtain individual responses? What is the relationship between users' perceived enjoyment and their intention to conduct screenshot-based interactions? What are the effects of three factors (perceived enjoyment, colleague opinion, and personal innovativeness) on TAM variables (such as perceived ease of use, perceived usefulness, and behavioral intention) when measuring the adoption of screenshot-based interactions?

2. Literature review

As the aim of this study was to investigate the antecedents of screenshot-based interactions, several theories were used as a basis for the study. Next, user acceptance of screenshot-based interaction was measured. Much of the existing user-acceptance research has focused on TAM and its extensions, which are based on motivation theory; however, less effort has been made to explore TAM from the perspective of personality traits. Both motivation theory and personality-trait theory offered means of identifying possible antecedents for TAM. Therefore, we investigated not only the effects of the TAM-based fundamental factors on user acceptance of screenshot-based interaction, but also supplementary factors such as intrinsic motivation and personality traits.

2.1. Media richness theory

Vygotsky's cognitive development theory (Vygotsky, 1977) states that an individual's cognitive development is generated through his or her interactions with people and environments, and that the individual internalizes these external stimuli, which become personal knowledge. The emphasis is on the relation between social interactions and experiences and the knowledge development process. Based on Vygotsky's theory, social constructivism hypothesizes that learning is socially constructed with active knowledge fabrication within its context, interaction, and circumstances (Salomon & Perkins, 1998). In other words, learning can be viewed as individual's interaction in a social process of knowledge construction.

With the rapid growth of computer and Internet technologies, e-learning has become a widely accepted learning method. Indeed, e-learning is a process of knowledge construction. Social constructivism provides a theoretical basis for e-learning systems that enable users to engage in interactive, creative, and collaborative activities during knowledge construction (Brandt, 1997). All types of media, such as text, image, audio, animation and video, can be used to present instructional materials on an e-learning platform. However, discussion and communication between users continue to be formatted as text, as in the case of discussion forums. When tasks entail a higher degree of equivocality and uncertainty, negotiation among users is more difficult in traditional discussion forums. This may explain Bartscha and Cobern's (2003) finding that the use of multimedia instructional materials does not necessarily have a significant effect on users' understanding of instructional content. As a consequence, e-learning systems should make effective use of media not only to present instructional materials but to enhance discussion and interaction between users.

According to the media-richness theory (Daft & Lengel, 1986), task performance is improved when task needs are matched to a medium's richness, as this enables users to communicate and thereby to improve their understanding. To enhance learners' understanding, therefore, the medium used to post a comment or question online should be as “rich” as possible.

The media-richness theory (Daft & Lengel, 1986; Daft et al., 1987) states that media vary in richness, with “richness” defined as the ability to enable users to convey information and thus to facilitate the acquisition of shared meaning and understanding within a given time interval. The efficiency ofcommunication between users is influenced not only by the fitness of the medium used, but also by the characteristics of the task, such as its degree of equivocality or uncertainty. Four criteria for media richness were proposed byDaft et al. (1987), as follows.

(1) *Immediate feedback*: the medium facilitates quick convergence on a common interpretation.
(2) *Personalization*: refers either to the conveyance of emotions and feelings, or to the ability of the medium to be tailored to the specific needs and perspective of the receiver.
(3) *Multiple cues*: an array of cues, such as physical presence, voice inflection, physical gestures, words, numbers, and graphic symbols, facilitate the conveyance of interpretation and meaning, rather than simply information or data.
(4) *Language variety*: numbers and formulas provide greater precision, but natural language conveys a broader set of concepts and ideas.

Face-to-face interaction is considered the richest medium. In order of decreasing richness, other possible media are the telephone, personal documents (e.g., memos), impersonal unaddressed documents (e.g., bulletins), and numeric reports (e.g., spreadsheets) (Daft et al., 1987, pp. 358–359). It is clear that media with higher levels of synchronicity, such as face-to-face communication or the telephone, exhibit greater richness. However, as Dennis and Valacich (1999) suggested, the “richest” medium for communication may not be the “best” one. The best medium or set of media depends on context. The present study, for instance, implemented a screenshot-based interaction system that could be regarded as a supplement to a traditional classroom course. After class, students were encouraged to use the screenshot-based interaction system to explain their problems and respond individually to others' problems. Therefore, asynchronous media were considered more suitable than synchronous ones in the context of screenshot-based interaction.

2.2. Technology acceptance model (TAM)

Over the last two decades, the technology acceptance model (TAM) has been used to measure user acceptance of new information technology. It is the most frequently used method across a wide variety of corporate ITs, and consistently explains about 40% of the variance in users' intention to use IT and actual usage (Venkatesh & Bala, 2008).

Several theories provide strong foundation for the TAM. First, the theory of reasoned action (TRA) has proved that people's behavior is directly influenced by their intention to perform, which is in turn affected by both their attitude and the subjective norm (Fishbein & Ajzen, 1975). Second, Ajzen (1985) proposed the theory of planned behavior (TPB) to more precisely predict individuals' behavior by developing a construct, namely perceived behavior control. Consistent with TRA and TPB, the TAM adopted the premise that users' beliefs about IT usage affect their attitudes, and further that users' ideas about the usefulness and perceived ease of use of new information technology are major determinants of users' attitudes, which lead to their behavioral intentions (Davis et al., 1989). In addition, user's behavioral intention regarding IT influences their actual usage behavior. However, by eliminating the attitude construct, Venkatesh and Davis (1996) proposed a final version of TAM with the chief consideration of external factors that might affect the beliefs of a person toward a new technology.

As Davis (1989) stated, TAM can be modified by adding appropriate constructs according to the specific context. Based on the TAM, several models such as TAM2 (Venkatesh & Davis, 2000), UTAUT (Venkatesh, Morris, Davis, & Davis, 2003) and TAM3 (Venkatesh & Bala, 2008) were developed one after another. However, it is not necessary for future user adoption studies to apply each construct from these modified models. Instead researchers need to carefully consider the appropriateness of these constructs in advance.

In the study, we investigate the interactions that occur between users when they are using screenshots to demonstrate their problems and to get respective responses. All users describe their problems or provide their opinions by sharing their screenshots on a screenshot-based interaction system. To clarify what a screenshot means, users can create a rectangle or a dialog box attached to a specific screenshot, which includes further explanation. As users interact with each other on a specific screenshot by creating other rectangles or dialog boxes, the interaction is termed "screenshot-based interaction." In fact, these screenshots function as boundary objects, which could improve the common representation and in turn increase the efficiency of communication between users (Star & Griesemer, 1989).

Furthermore, the screenshot function could supplement e-learning systems and should be provided to learners, especially advanced computer software learners. It is easier to describe or understand computer software problems with a screenshot and text, than with only text. Furthermore, in advanced computer software learning people encounter more unpredictable problems than in basic software learning. Users are not able to describe clearly their problems with higher level of uncertainty or equivocality. Thus, based on media richness theory, a screenshot-based interaction providing higher richness can overcome the difficulties described above. As the screenshot function described above is very similar to the photo-sharing function provided by some social networking sites, such as Flickr or Facebook, the implementation of screenshot-based interaction function in e-learning system is possible. However, it is still not available in most e-learning systems.

The subject of this study is advanced computer software learning, and the information technology measured is actual screenshot-based interaction. There is no doubt that TAM has successfully predicted and explained user acceptance of new IT (Dickinger et al., 2008; Yu, Ha, & Choi. 2005). Thus, the study treats TAM as a preferred model to measure user adoption, while appending appropriate constructs, and applies it to examine user acceptance of screenshot-based interactions. The hypotheses based on the TAM's fundamental constructs are proposed as follows.

Hypothesis 1. The higher the level of users' perceived ease of use, the higher the level of their perceived usefulness for screenshot-based interaction.

Hypothesis 2. The higher the level of users' perceived ease of use, the higher the level of their behavioral intention to conduct screenshot-based interactions.

Hypothesis 3. The higher the level of users' perceived usefulness, the higher the level of their behavioral intention to conduct screenshot-based interactions.

As Dishaw and Strong (1999) stated, one main weakness of the TAM is its lack of task focus. The TAM does not fully reflect the variety of user task environments (Moon & Kim, 2001). Therefore, one obstacle to using TAM has been problems in applying it beyond the workplace. To increase the validity of the TAM, it is necessary to further explore specific contextual factors that may influence the user's adoption of IT. Thus, given the specific context of this study, three constructs, including user's perceived enjoyment, colleague opinion and innovative personality, were used to extend the TAM.

2.3. Perceived enjoyment

Based on motivation theories, Igbaria, Parasuraman, and Baroudi (1996) have proved that system usage is influenced by one extrinsic and one intrinsic motivation, namely perceived usefulness and perceived fun, which is similar to the concept of perceived enjoyment. Van der Heijen (2004) stated that perceived enjoyment is an important addendum to the TAM when explaining user acceptance of information systems. Dickinger et al. (2008) also indicated that perceived enjoyment is an important antecedent for the adoption of technology with network externalities. Thus, users' perceived enjoyment, which focuses on the interaction between an individual and the situation, has become a critical supplement to explaining individual acceptance of new IT.

In addition to the TAM related constructs, quite a few researchers have proposed that user's perceived enjoyment is essential to information systems usage. For example, Liaw and Huang (2003) found that user's perceived enjoyment is an important factor affecting individual's decisions to use search engines as an information retrieval tool. Lee, Cheung, and Chen (2005) also showed that both perceived usefulness and perceived enjoyment significantly and directly influenced students' intention to use Internet-based learning mediums. Yu et al. (2005) also found that perceived enjoyment is the most important factor affecting attitude and behavioral intention toward e-commerce, which is electronically mediated commerce using interactive television.

Extending the concept of perceived enjoyment, Moon and Kim (2001) proposed perceived playfulness as a more comprehensive set of motivation states; it includes three constructs: concentration, curiosity and enjoyment. However, of the three perceived playfulness constructs, enjoyment is the most relevant to our study. Because users' effort made in each screenshot-based interaction is quick and very short-term, neither their concentration nor curiosity is easily observed. Therefore, the proposed study only adopts the enjoyment construct. As the study implemented a discussion forum with a highly interactive media as the preferred environment for screenshot-based interactions, this environment is relatively easy to access and use. All posted contents, including rectangles, dialog boxes or screenshots, can be accessed and reviewed by anyone. Thus, the enjoyment of social interaction can be predictably generated. As Moon and Kim (2001) proved that perceived ease of use was affected by perceived playfulness, including concentration, curiosity and enjoyment, Hypothesis 4 is proposed as follows.

Hypothesis 4. The higher the level of users' perceived ease of use, the higher the level of users' perceived enjoyment for screenshot-based interaction.

Furthermore, Martocchio and Webster (1992) found that users experiencing a higher degree of enjoyment showed greater affective responses to computer-training tasks. In other words, perceived enjoyment cultivates a positive attitude toward computer-software learning. Based on this argument, the following hypothesis was proposed.

Hypothesis 5. The higher the level of users' perceived enjoyment, the greater their intention to conduct screenshot-based interactions.

2.4. Colleague opinion

Due to the need for social companionship, users tend to concur with their colleagues' opinions on new information technology (Lewis et al., 2003). In the context of IS, Kim and Kankanhalli (2009) found that favorable colleague opinion, defined as the perception that colleagues favor the changes related to a new IS implementation, has a negative effect on user resistance. Thus, colleague opinion has a normative influence on users in their work environment. It follows that colleague opinion has a positive influence on users' willingness to adopt new information systems. Students, in particular, are easily influenced by their peers. The opinions of their peers are often more important to them than those of their teachers. In this study, “colleague opinion” was understood to refer to classmates' opinions of using screenshot-based interactions.

Furthermore, Kim and Kankanhalli (2009) described colleague opinion as a kind of subjective norm, which had already been identified as an antecedent of TAM (Venkatesh & Davis, 2000). Therefore, the present study included colleague opinion as an antecedent of TAM, because it may indirectly affect users' behavioral intentions with regard to the adoption of new information technology. Based on this reasoning, the following hypotheses were proposed.

Hypothesis 6. The higher the level of positive colleague opinion, the greater users' perceived enjoyment of conducting screenshot-based interactions.

Hypothesis 7. The higher the level of positive colleague opinion, the greater the perceived ease of using screenshot-based interactions.

Hypothesis 8. The higher the level of positive colleague opinion, the higher the perceived usefulness of conducting screenshot-based interactions.

2.5. Personal innovativeness

There is a large amount of research on technology and innovation adoption, some of it focusing on the factors that affect adoption at different stages. For instance, Rogers (1995) proposed diffusion of innovation theory (DIT), and classified adopters into five categories, namely innovators, early adopters, early majority, late majority and laggards. This is an interesting attempt to relate user's personality traits to their adoption rate. In examining the relationship between adoption rate and adopter types, Lin (1998) used theories of adoption of innovations to explain adoption dynamics, and defined innovativeness as “the degree to which an individual or other unit of adoption is relatively earlier in adopting an innovation than other members of a social system” (Rogers, 1995, p. 22). When people try to actualize their need for innovativeness, they must look forward to and keep up with innovative ideas (Lin, 1998). This phenomenon is a reflection of people's desire for innovativeness.

Besides, Busselle, Reagan, Pinkleton, and Jackson (1999) investigated the factors that affect the usage of an innovation after it becomes available to the wider population. Foxall and Bhate (1991) also included personality styles in their exploration of the antecedents of individual innovativeness. Hirschman (1980) proposed that those with more desire for novelty may be more willing to adopt an innovation. In addition to examining the relationship between users' need for innovativeness and their adoption of personal computers (Lin, 1998), Lin (2004) verified the relationship between the use of webcasting and user innovativeness, termed “personal innovativeness” in the present study. According to the diffusion-of-innovations theory and the findings of related research, personal innovativeness is an important antecedent of new-technology adoption.

Based on the foregoing reasoning, this study aimed to investigate the effects of users' characteristics, specifically their personal innovativeness, on their perception of the ease of use and usefulness of conducting screenshot-based interactions. The following hypotheses were proposed.

Hypothesis 9. The greater users' personal innovativeness, the stronger their perception of the ease of use of using screenshot-based interactions.

Hypothesis 10. The greater users' personal innovativeness, the stronger their perception of the usefulness of conducting screenshot-based interactions.

The complete research model for the study is shown in Fig. 3. Each of the TAM-hypothesized relationships, as shown inside the dotted lines, was examined. In addition to the direct effect of users' perceived enjoyment on their intention to conduct screenshot-based

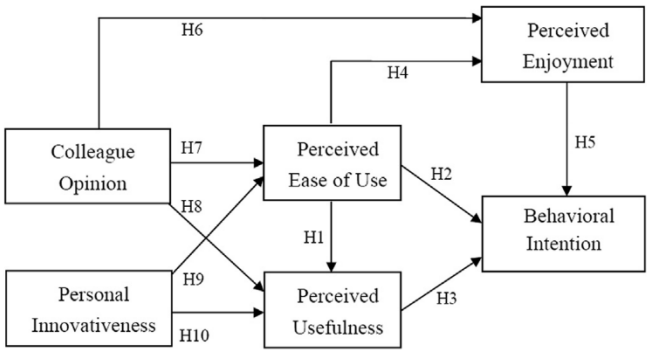

Fig. 3. Research model.

interactions, the direct effects of users' personal innovativeness on their perception of, respectively, the system's ease of use and usefulness were also measured.

3. Research method

3.1. Subjects

Four hundred and forty-one undergraduates majoring in information systems from six sections of the same Linux operating system course were recruited. As a major part of the course requirement, students were required to hand in their homework and describe their problems using a screenshot-based interaction system. They uploaded screenshots and were encouraged to respond to all of the screenshots. All of the students and the lecturer could discuss and share their opinions by dragging rectangles or leaving comments in text boxes above specific screenshots, as shown in Fig. 3. These students were quite familiar with using screenshots, as they all had experience using social networking media, such as Facebook or Flickr. Each class was taught by the same instructor, using the same teaching materials and under the same learning conditions. This course has been offered for the past ten consecutive years.

While using the screenshot-based interaction system, two types of student usage patterns were evident. They can be summarized as follows.

3.1.1. Passive participation

When a piece of homework was assigned, the students received a notification to remind them to complete it. Once they did so, they uploaded their screenshots by clicking the first icon in the screenshot panel, as shown in Fig. 4. These screenshots were then uploaded and stored in the respective location in the system, and could be browsed immediately in the exploration section, as shown in Fig. 5.

When the other students had questions about the information displayed in the specific screenshot, they left annotations on it. Clicking the first or third icon in the annotation panel created rectangles or text boxes to answer the questions, as shown in Fig. 5. Clicking the second icon in the annotation panel saved a rectangle after its position and size was confirmed, and a text box was generated as shown in Fig. 1. This behavior was described as two kinds of passive participation.

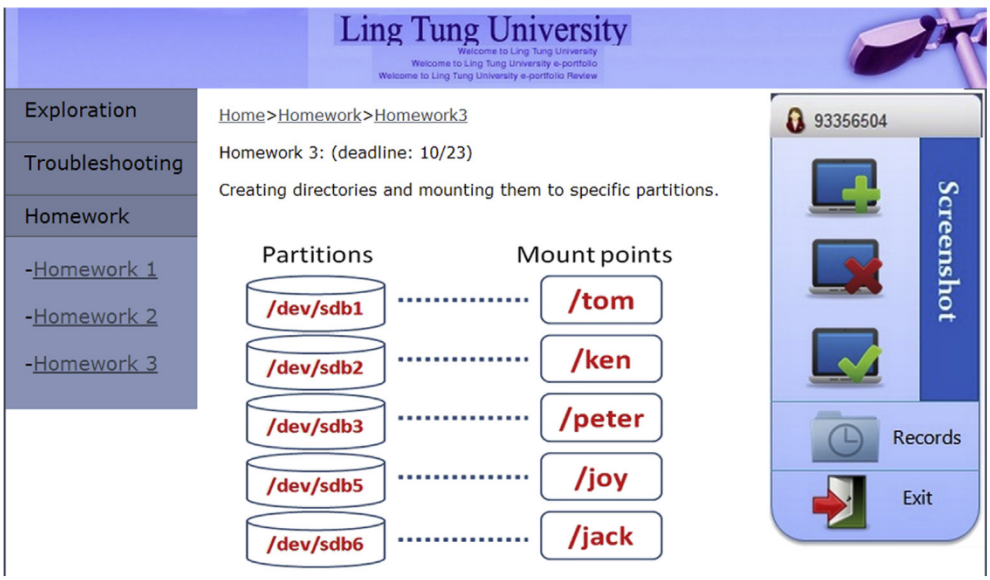

Fig. 4. Homework section with screenshot panel.

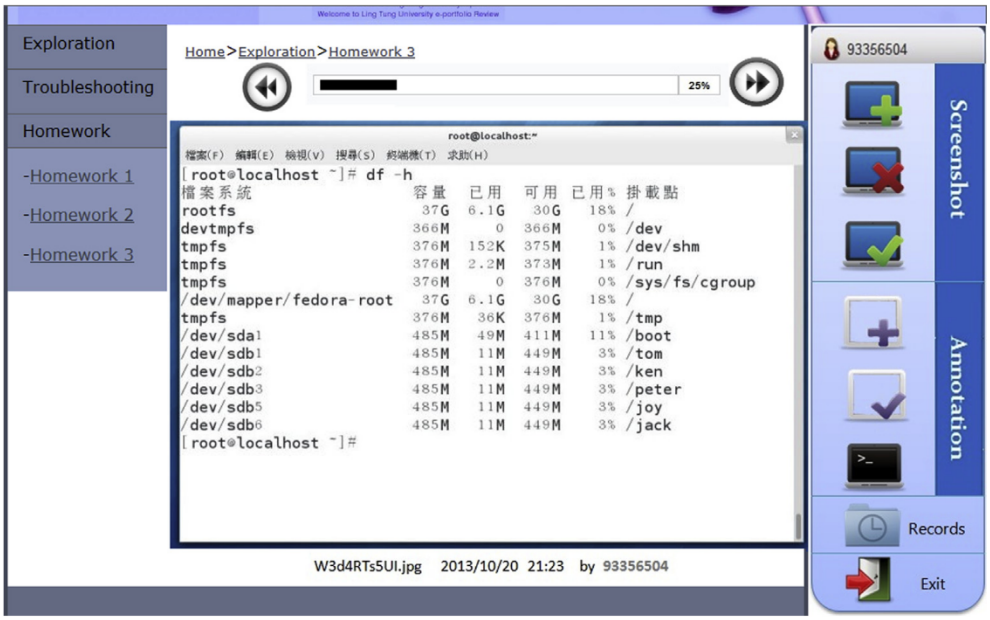

Fig. 5. Exploration section with screenshot and annotation panels.

3.1.2. *Active participation*

When the students had problems with the homework, they could report the status of the computer software by uploading their screenshots. They submitted the screenshots as troubleshooting requests by clicking the second icon in the screenshot panel, as shown in Fig. 4. These screenshots soon appeared in the troubleshooting section, as shown in Fig. 6.

Of course, any screenshots that were unrelated to any homework were welcomed and acceptable, and could be uploaded to the exploration section by clicking the first icon in the screenshot panel, as shown in Fig. 5. When the students arrived at new findings, they could share them with their classmates by creating their own screenshots and annotations.

Moreover, while browsing screenshots to troubleshoot a problem, the students were able to provide feasible solutions with explanations for others. They could make use of the icons in the annotation panel, as shown in Fig. 6, to arrange annotations including rectangles and text boxes. This behavior was considered a kind of active participation.

3.2. *Procedures*

To investigate how screenshot-based interactions affect the learning of advanced computer software, questionnaires were administered to all 441 students. The students were aware that they were involved in a project but were blinded to the research hypotheses.

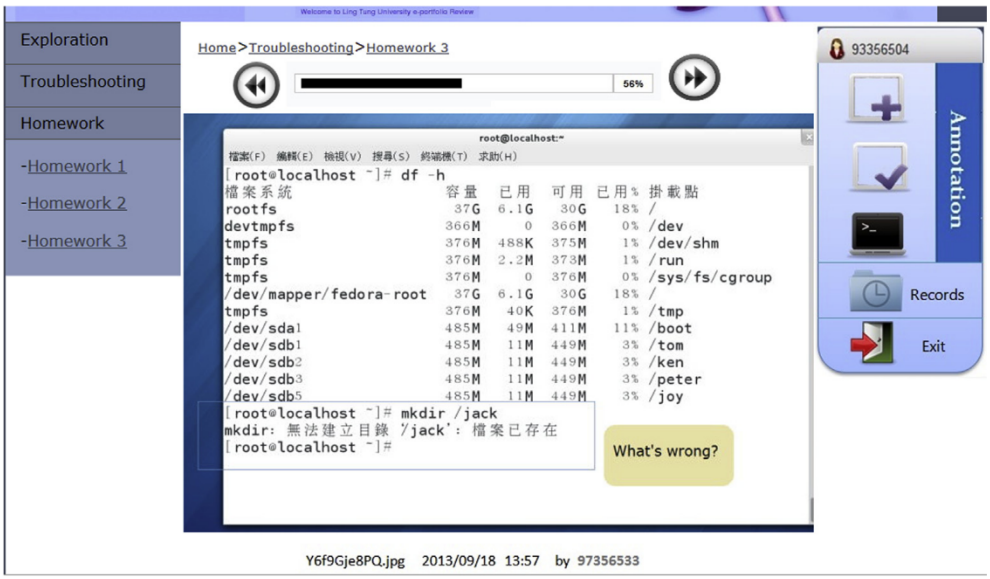

Fig. 6. Troubleshooting section with annotation panel.

The questionnaire survey administered to the students assessed the perceived ease of use, perceived usefulness, perceived enjoyment, innovative personality, colleague opinion, and behavioral intention after using the screenshots to demonstrate their problems and to reply to other students' questions in the context of learning Linux. The research model shown in Fig. 3 was tested and all of the hypotheses were examined through structural equation modeling using the collected data.

3.3. Measurement

The dependent variables were students' perceived ease of use, perceived usefulness, perceived enjoyment, colleague opinion, and innovative personality. The independent variable was students' behavioral intention. All students were asked to evaluate the content validity of the measurement items using a Likert scale of 1–7, where 7 represented "strongly agree" and 1 represented "strongly disagree." The measurement of each construct is further described as follows.

3.3.1. Perceived ease of use and perceived usefulness

The items used to measure perceived ease of use (4 items) and perceived usefulness (3 items) were adapted from the Davis (1993) scale with modifications. They focused on measuring students' ease of use and usefulness perceptions in relation to the screenshot-based interaction. Both scales have been confirmed to have high levels of flexibility, reliability, and generalizability in a number of studies. Cronbach's α for perceived ease of use and perceived usefulness were .934 and .890, respectively.

3.3.2. Behavioral intention

The items that measured behavioral intention (3 items) were adapted from the Ajzen and Fishbein (1980) scale and measured the degree of the student's intention to conduct screenshot-based interactions. The Cronbach's α for this three-item measure was .898.

3.3.3. Perceived enjoyment

According to Moon and Kim (2001) perceived playfulness has three aspects: concentration, curiosity and enjoyment. Of the three, enjoyment is most relevant to our study, because the other constructs are not easily observed in the context of screenshot-based interactions. Therefore, we used Moon and Kim's concept of enjoyment and called it "perceived enjoyment", defining it as the degree to which an individual's statements made while conducting a screenshot-based interaction reflected enjoyment. Moon and Kim's three measurement items of enjoyment were applied to measure the students' perceived enjoyment. Cronbach's α for this three-item measure was .915.

3.3.4. Colleague opinion

Kim and Kankanhalli (2009) developed a scale to assess colleague opinion as perceived by users. The scale includes three items measure the degree of classmates' positive opinions about screenshot-based interactions. Cronbach's α for this three-item measure was .788.

3.3.5. Personal innovativeness

Lin (1998) developed a scale to assess a user's innovative personality, which was defined as a user's desire for innovative ideas or products. The scale includes four items that measure the degree of an individual's interest and involvement in keeping up with innovative ideas or products. One item was eliminated on the basis of an item-total correlation test. Cronbach's α for the remaining three-item measure was .948.

4. Results

4.1. Data analysis

Of the 441 students attending the class, 418 completed the questionnaires, giving a response rate of 94.7%. The correlations between the variables were tested using Pearson's correlation coefficient. As shown in Table 2, all of the variables were positively interrelated. The behavioral intention was highly correlated with both colleague opinion and perceived enjoyment ($r > .6$), whereas innovative personality was weakly correlated with the other variables ($.2 < r < .4$). However, correlation does not imply causation. The causal relationship between the variables was further examined using structural equation modeling.

All the values of composite reliability were higher than the recommended cutoff of 0.6. Thus, the measurements showed an acceptable level of internal consistency.

Two tests were applied to evaluate the convergent validity and discriminant validity (Hair, Black, Babin, & Anderson, 2010). High loadings on a factor indicated that the items converged on a construct, suggesting high convergent validity. As depicted in Table 1, the factor loadings of the measures on their respective constructs ranged from 0.67 to 0.95, all significant at the 0.1% level. Factor loadings exceeding 0.5 were regarded as practically significant. Hence, the measurement model demonstrated adequate convergence. Furthermore, when the square root of the average variance extracted (AVE) for each construct is compared with the correlations between it and the other constructs, each construct should share a greater variance with its own measurement items. Our analysis showed that the AVE for each construct was higher than the inter-construct correlations, as shown in Table 2. Thus, the measurements had good discriminant validity.

4.2. Structural model

Using the 418 records, the proposed model was assessed with maximum likelihood estimation using AMOS. All of the calculations were based on the covariance matrix of the variables. Five common model-fit measures were used to assess the model's overall goodness of fit, the ratio of χ^2 to degrees of freedom (CMIN/DF), goodness-of-fit (GFI), adjusted goodness-of-fit index (AGFI), comparative fit index (CFI), and root mean square error of approximation (RMSEA).

Table 1
Factor loadings for six constructs ($N = 418$).

Construct Items	Mean	S. D.	Loadings
Colleague opinion			
Most of my classmates think that using screenshots to interact with each other is a good idea.	4.52	1.09	0.78
My classmates support the use of screenshots to interact with each other.	4.43	1.18	0.77
Most classmates encourage me to use screenshots to interact with others.	4.11	1.14	0.67
Personal innovativeness			
I am willing to learn new ideas.	5.34	1.04	0.93
I am willing to explore new technology.	5.36	1.02	0.95
I keep up with new technology.	5.37	1.05	0.90
Perceived enjoyment			
Using screenshots to interact with others is an enjoyable way to learn.	4.50	1.21	0.86
Using screenshots to interact with others is a fun way to learn.	4.32	1.17	0.92
Using screenshots to interact with others keeps me happy while learning.	4.43	1.18	0.87
Perceived ease of use			
Learning to use screenshots to interact with others is easy for me.	4.82	1.34	0.82
The process of using screenshots to interact with others is clear and understandable.	4.86	1.33	0.94
It is easy to upload screenshots and to respond to screenshots.	4.67	1.44	0.91
Overall, I believe that it is easy to use screenshots to interact with others.	4.64	1.35	0.87
Perceived usefulness			
Using screenshots to interact with others helps me to learn more efficiently.	4.79	1.19	0.83
Using screenshots to interact with others improves my academic performance.	4.66	1.20	0.90
Using screenshots to interact with others makes my learning more effective.	4.58	1.19	0.83
Behavioral intention			
In future, I will use screenshots to interact with others on a regular basis while learning advanced computer software.	4.16	1.30	0.89
In future, I will frequently use screenshots to interact with others while learning advanced computer software.	4.03	1.26	0.90
In future, I will strongly recommend using screenshots to interact with others while learning advanced computer software.	4.25	1.24	0.81

The results indicated that the proposed model (CMIN/DF = 2.928; GFI = .906, AGFI = .873, CFI = .958, RMSEA = .068) had a good fit, because all of the criteria were better than the recommended values (CMIN/DF < 3; GFI > .90, AGFI > .80, CFI > .90, RMSEA < .80). We thus used the model to examine our hypotheses.

As shown in Fig. 7, all of the standardized path coefficients of the TAM fundamental relationships, except the path running from perceived ease of use to perceived usefulness, were statistically significant; thus Hypotheses 2 and 3 were supported, whereas Hypothesis 1 ($\beta = .096$, $p < .05$) was not.

The path running from perceived ease of use to perceived enjoyment and the path from perceived enjoyment to behavioral intention were both statistically significant, thereby supporting Hypotheses 4 and 5.

The paths running from colleague opinion to perceived enjoyment, perceived ease of use, and perceived usefulness were all statistically significant, confirming Hypotheses 6–8.

Although the relationship between an innovative personality and perceived ease of use was significant, the relationship between an innovative personality and perceived usefulness was not. Thus, Hypothesis 9 was supported, but Hypothesis 10 was not confirmed ($\beta = .089$, $p < .05$).

Although perceived enjoyment and perceived usefulness had a direct positive effect on behavioral intention, perceived ease of use had both a direct and an indirect effect; it had a direct effect on the perceived enjoyment, and thus an indirect effect on behavioral intention. In addition, colleague opinion had a direct effect on perceived enjoyment, perceived ease of use, and perceived usefulness, and through them affected behavioral intention indirectly. The R^2 value indicated that 52% of the variance in users' behavioral intention was explained by these variables.

Table 3 shows the total effects, as determined by the path analysis. They were calculated by combining the direct and indirect effects of the five independent variables. Confirming the direct and indirect effects of these variables on users' intention to conduct screenshot-based interactions enables us to improve advanced computer learning in practice.

First, both perceived enjoyment (total effect = .50) and perceived usefulness (total effect = 0.24) had direct effects on behavioral intention. Second, perceived ease of use not only had a direct effect on behavioral intention (direct effect = .12), but also an indirect effect (indirect effect = .16). Consequently, the total effect of perceived ease of use was .28, but its indirect effect was greater than its direct effect.

Table 2
Construct reliability, AVE and correlations ($N = 418$).

Construct	Composite reliability	Construct						
		AVE	1	2	3	4	5	6
1 Colleague opinion	.785	.550	**.74**					
2 Personal innovativeness	.948	.859	.37**	**.93**				
3 Perceived ease of use	.936	.785	.44**	.31**	**.89**			
4 Perceived usefulness	.889	.729	.51**	.33**	.40**	**.85**		
5 Perceived enjoyment	.914	.781	.51**	.26**	.55**	.46**	**.88**	
6 Behavioral intention	.901	.753	.62**	.27**	.48**	.49**	.62**	**.87**

Note. **$p < .01$. Diagonal elements (in bold) are the square root of the average variance extracted (AVE). Off-diagonal elements are the correlations among constructs. For discriminant validity, diagonal elements should be greater than off-diagonal elements.

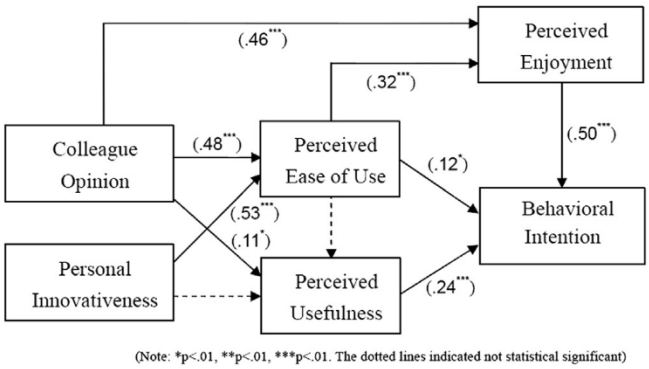

Fig. 7. Standardized path coefficients of the proposed model.

Although it did not have a direct effect on behavioral intention, colleague opinion had direct effects on perceived usefulness, perceived ease of use, and perceived enjoyment, whereas personal innovativeness only had a direct effect on perceived ease of use. Hence, both antecedents, namely colleague opinion and personal innovativeness positively affected behavioral intention indirectly.

This study emphasized the effects of TAM extending factors, including perceived enjoyment, colleague opinion and personal innovativeness, rather than the TAM fundamental relationships while measuring user acceptance of the screenshot-based interaction system.

Overall, students' personal innovativeness was found to have a positive influence on their perceived ease of use, but no significant effect on their perceived usefulness. A possible explanation for the first finding is that students with a stronger desire for novelty tried harder to comprehend the use of screenshot-based interaction and overcome any difficulties, which increased their perceived ease of use. The second finding may be explained by the fact that the desire for novelty is unlikely to have affected students' perceptions of the usefulness of conducting screenshot-based interactions. In short, screenshot-based interaction is not only suitable but also helpful for students exhibiting different levels of personal innovativeness.

Contrary to our expectations, students' perceived ease of use was found to have no significant effect on the perceived usefulness of conducting screenshot-based interactions. A plausible explanation is that regardless of the degree of difficulty the students attributed to the use of screenshot-based interaction, they all considered it to be useful.

In fact, the screenshot-based interaction system is in the prototype stage and requires more comprehensive functionality. For example, to allow for a full discussion, all of the annotations including the rectangles and text boxes were designed to be anonymous in the early stages of the study. However, because the screenshots a student uploaded can be found and summarized by clicking the “Records” button, as shown in Fig. 4, the annotations he/she created cannot be traced. This limits the study in calculating the quantity of personal annotations and further measuring the effect of annotations on learning performance. Therefore, we suggest that personal annotations should be recorded and traced in the future, regardless of whether they are anonymous.

There are only two types of annotations in this study: rectangles and text boxes. Other types of annotations may be considered in the future, such as circles, stars and even non-regular lines. Furthermore, some meaningful icons can be included as annotations for quick responses rather than entering words into text boxes. Such icons are used in most instant messaging services such as MSN, LINE and Messenger. We believe these settings will generate more interest for users to use the screenshot-based interaction system, and will lead to an increase in their perceived enjoyment.

Finally, several pieces of homework were assigned to enhance the usage of the screenshot-based interaction system. We expected that completing the homework would facilitate a minimum amount of screenshot-based interactions among students. Although most of the students handed in their homework on time, some were unable to complete it accurately. They seemed to refuse to upload their screenshots for troubleshooting purposes. The reasons for this remain unknown and require further investigation.

5. Conclusion

During this study, a screenshot-based interaction system for advanced computer software learners was implemented. This was accompanied by empirical examination of the effects of students' personal innovativeness, colleague opinion, and perceived enjoyment,

Table 3
Path analysis.

From	To	Direct effects	Indirect effects	Total effects
Perceived ease of use →	Behavioral intention	.12	.16	.28
Perceived usefulness →		.24	–	.24
Perceived enjoyment →		.50	–	.50
Colleague opinion →		–	.39	.39
Personal innovativeness →		–	.15	.15
Colleague opinion →	Perceived enjoyment	.46	.15	.61
Perceived ease of use →		.32	–	.32
Personal innovativeness →		–	.17	.17
Personal innovativeness →	Perceived ease of use	.53	–	.53
Colleague opinion →		.48	–	.48
Colleague opinion →	Perceived usefulness	.11	–	.11

Note. Total effects = direct effects + indirect effects (Hair et al., 2010, pp. 630–635).

along with factors fundamental to TAM, such as perceived ease of use and perceived usefulness, on their intention to conduct screenshot-based interactions.

A very important practical implication of our findings is the possibility of improving students' performance in advanced computer software learning by introducing a screenshot-based interaction system, which can facilitate discussion and cooperative learning by making good use of higher-richness media, specifically screenshots. Conducting screenshot-based interactions is a fairly involved process that will require the teacher to prepare a lot of information for questions and put the time into managing screenshots. One of the main features of screenshot-based interaction is that students tackle questions that prompt higher-level thinking. To increase students' willingness to conduct screenshot-based interactions, teachers should concentrate on finding ways to enhance their perceived enjoyment of screenshot-based interaction, and their perception of favorable colleague opinion. Although colleague opinion was not found in this study to have a direct effect on behavioral intention, its indirect effect was clear from its direct effects on perceived enjoyment, the perceived ease of use and usefulness of screenshot-based interaction.

The findings of this study contribute to the development of theories concerning the effect of colleague opinion on behavioral intention. By identifying possible antecedents of students' intention to conduct screenshot-based interactions, this study also contributes substantially to existing research on means of enhancing the problem-solving abilities of advanced computer software learners.

As the factors in the theories mentioned above jointly explain most of the variance of user acceptance, other determinant is still unknown and needed to be further explored in specific context. In addition, the research results may be linked to the subject being taught. Therefore, to confirm the applicability of the result for different course subjects, especially courses in other advanced computer software learning, the research model needs to be tested various times. When the categorization of course subjects is systemized and more studies are accumulated, general conclusion can be drawn with higher confidence.

Acknowledgements

This research is partially supported by Ministry of Science and Technology in Taiwan under project neumber MOST-103-2410-H-275-006-MY2. The author wish to thank anonymous reviewers for their helpful feedback and suggestions.

References

Adams, D. A., Nelson, R. R., & Todd, P. A. (1992). Perceived usefulness, ease of use, and usage of information technology: a replication. *MIS Quarterly, 16*(2), 227–247.
Ajzen, I. (1985). From intention to actions: a theory of planned behavior. In J. Kuhl, & J. Bechmann (Eds.), *Action-control: From cognition to behavior* (pp. 11–39). Heidelberg, Germany: Springer.
Ajzen, I., & Fishbein, M. (1980). *Understanding attitudes and predicting social behaviour*. Engelwood Cliffs, NJ: Prentice-Hall.
Bartscha, R. A., & Cobern, K. M. (2003). Effectiveness of powerpoint presentations in lectures. *Computers & Education, 41*, 77–86.
Brandt, D. A. (1997). Constructivism: teaching for understanding of the Internet. *Communications of the ACM, 40*(10), 112–117.
Busselle, R., Reagan, J., Pinkleton, B., & Jackson, K. (1999). Factors affecting internet use in a saturated-access population. *Telematics and Informatics, 16*(1–2), 45–58.
Chen, Y. C., Hwang, R. H., & Wang, C. Y. (2012). Development and evaluation of a Web 2.0 annotation system as a learning tool in an e-learning environment. *Computers & Education, 58*, 1094–1105.
Chin, W. C., & Todd, P. A. (1995). On the use, usefulness and ease of use of structural equation modeling in MIS research. *MIS Quarterly, 19*(2), 237–246.
Chow, M., Herold, D. K., Choo, T. M., & Chan, K. (2012). Extending the technology acceptance model to explore the intention to use second life for enhancing healthcare education. *Computer & Education, 59*, 1163–1144.
Daft, R. L., & Lengel, R. H. (1986). Organizational information requirements, media richness and structural design. *Management Science, 32*(5), 554–571.
Daft, R. L., Lengel, R. H., & Trevino, L. K. (1987). Message equivocality, media selection and manager performance: implications for information systems. *MIS Quarterly, 11*, 355–366.
Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS Quarterly, 13*(3), 319–340.
Davis, F. D., Bagozzi, R. P., & Warshaw, P. R. (1989). User acceptance of computer technology: a comparison of two theoretical models. *Management Science, 35*(8), 982–1003.
Davis, F. D. (1993). User acceptance of information technology: system characteristics, user perceptions and behavioural impacts. *International Journal of Man-Machine Studies, 38*(3), 475–487.
Dennis, A. R., & Valacich, J. S. (1999). Rethinking media richness: towards a theory of media synchronicity. In *Proceedings of the 32nd Annual Hawaii International Conference on System Sciences, Maui, HI*.
Dickinger, A., Arami, M., & Meyer, D. (2008). The role of perceived enjoyment and social norm in the adoption of technology with network externalities. *European Journal of Information Systems, 17*, 4–11.
Dishaw, M. T., & Strong, D. M. (1999). Extending the technology acceptance model with task-technology fit constructs. *Information & Management, 36*(1), 9–21.
Doll, W. J., Hendrickson, A., & Deng, X. (1998). Using Davis's perceived usefulness and ease-of-use instruments for decision making: a confirmatory and multi-group invariance analysis. *Decision Sciences, 29*(4), 839–869.
Fishbein, M., & Ajzen, I. (1975). *Belief, attitude, intention and behavior: An introduction to theory and research*. Reading, MA: Addison-Wesley.
Foxall, G. R., & Bhate, S. (1991). Psychology of computer use: XIX. Extent of computer use: relationships with adaptive-innovative cognitive style and personal involvement in computing. *Perceptual and Motor Skills, 72*(1), 195–202.
Gao, F. (2013). A case study of using a social annotation tool to support collaboratively learning. *Internet and Higher Education, 17*, 76–83.
Gao, Q., Dai, Y., Fan, Z., & Kang, R. (2010). Understanding factors affecting perceived sociability of social software. *Computers in Human Behavior, 26*, 1846–1861.
Hair, J. F., Black, W. C., Babin, B. J., & Anderson, R. E. (2010). *Multivariate data analysis* (7th ed.). Upper Saddle River, NJ: Prentice Hall.
Hirschman, E. C. (1980). Innovativeness, novelty seeking, and consumer creativity. *Journal of Consumer Research, 7*(3), 283–295.
Hwang, W. Y., Wang, C. Y., & Sharples, M. (2007). A study of multimedia annotation of Web-based materials. *Computers & Education, 48*, 680–699.
Igbaria, M., Parasuraman, S., & Baroudi, J. J. (1996). A motivational model of microcomputer usage. *Journal of Management Information Systems, 13*(1), 127–143.
Kim, H., & Kankanhalli, A. (2009). Investigating user resistance to information systems implementation: a status quo bias perspective. *MIS Quarterly, 33*(3), 567–582.
Lee, M. K. O., Cheung, C. M. K., & Chen, Z. (2005). Acceptance of internet-based learning medium: the role of extrinsic and intrinsic motivation. *Information & Management, 42*(8), 1095–1104.
Lewis, W., Agarwal, R., & Sambamurthy, V. (2003). Sources of influence on beliefs about information technology use: an empirical study of knowledge workers. *MIS Quarterly, 27*(4), 657–678.
Liaw, S., & Huang, H. (2003). An investigation of user attitudes toward search engines as an information retrieval tool. *Computers in Human Behavior, 19*(6), 751–765.
Lin, C. A. (1998). Exploring personal computer adoption dynamics. *Journal of Broadcasting & Electronic Media, 42*(1), 95–112.
Lin, C. A. (2004). Webcasting adoption: technology fluidity, user innovativeness and media substitution. *Journal of Broadcasting & Electronic Media, 48*(3), 446–465.
Martocchio, J. J., & Webster, J. (1992). Effects of feedback and cognitive playfulness on performance in microcomputer software training. *Personnel Psychology, 45*, 553–578.
Moon, J. W., & Kim, Y. G. (2001). Extending the TAM for a World-Wide-Web context. *Information & Management, 38*(4), 217–230.
Munneke, L., Andriessen, J., Kanselaar, G., & Kirschner, P. (2007). Supporting interactive argumentation: influence of representational tools on discussing a wicked problem. *Computers in Human Behavior, 23*, 1072–1088.
Ngai, E. W. T., Poon, J. K. L., & Chan, Y. H. C. (2007). Empirical examination of the adoption of WebCT using TAM. *Computers & Education, 48*, 250–267.
Ralph, W. (1991). *Help! the art of computer technical support*. Berkeley, CA: Peachpit Press.

Rogers, E. M. (1995). *Diffusion of innovations* (4th ed.). New York, NY: Free Press.
Salomon, G., & Perkins, D. (1998). Individual and social aspect of learning. *Review of Research in Education, 23*, 1–24.
Samuel, R. D., Kim, C., & Johnson, T. E. (2011). A study of a social annotation modeling learning system. *Journal of Educational Computing Research, 45*(1), 117–137.
Sanchez, R. A., & Hueros, A. D. (2010). Motivational factors that influence the acceptance of Moodle using TAM. *Computers in Human Behavior, 26*, 1632–1640.
Segars, A. H., & Grover, V. (1993). Re-examining perceived ease of use and usefulness: a confirmatory factor analysis. *MIS Quarterly, 17*(4), 517–525.
Star, S. L., & Griesemer, J. R. (1989). Institutional ecology, "translations," and boundary objects: amateurs and professionals in Berkeley's museum of vertebrate zoology, 1907–39. *Social Studies of Science, 19*, 387–420.
Su, A. Y. S., Yang, S. J. H., Hwang, W. Y., & Zhang, J. (2010). A Web 2.0-based collaborative annotation system for enhancing knowledge sharing in collaborative learning environments. *Computers & Education, 55*, 752–766.
Van der Heijen, H. (2004). User acceptance of hedonic information systems. *MIS Quarterly, 28*(4), 695–704.
Venkatesh, V., & Bala, H. (2008). Technology acceptance model 3 and a research agenda on interventions. *Decision Science, 39*(2), 273–315.
Venkatesh, V., & Davis, F. D. (1996). A model of the antecedents of perceived ease of use: development and test. *Decision Sciences, 27*(3), 451–481.
Venkatesh, V., & Davis, F. D. (2000). A theoretical extension of the technology acceptance model: four longitudinal field studies. *Management Science, 46*(2), 186–204.
Venkatesh, V., Morris, M. G., Davis, G. B., & Davis, F. D. (2003). User acceptance of information technology: toward a unified view. *MIS Quarterly, 27*(3), 425–478.
Vygotsky, L. (1977). The development of higher psychological functions. *Soviet Psychology, 16*, 60–73.
Yang, H., & Lai, C. (2010). Motivations of Wikipedia content contributors. *Computers in Human Behavior, 26*, 1377–1383.
Yu, J., Ha, I., & Choi, M. (2005). The technology acceptance model: its past and its future in health care. *Information & Management, 42*(7), 965–976.